NESTING ECOLOGY OF THE NEAR THREATENED COLONIAL WATERBIRD BLACK-HEADED IBIS *THRESKIORNIS MELANOCEPHALUS* IN BHITARKANIKA MANGROVES, ODISHA

G.V. Gopi[1,2] and Bivash Pandav[1,3]

[1]Department of Endangered Species Management, Wildlife Institute of India, P.O. Box 18, Chandrabani, Dehradun 248 001, Uttarakhand, India.
[2]Email: gopigv@wii.gov.in
[3]Email: bivash.pandav@wii.gov.in

We present here the summary of our findings on the nesting ecology of Black-headed Ibis *Threskiornis melanocephalus* in Bhitarkanika heronry, one of the largest mixed-species heronries in India. A total count of nest trees and number of nests of all species carried over three years revealed the presence of 13,704 nests in 3,839 trees (2004), 11,249 nests on 3,237 trees (2005) and 11,819 nests on 4,221 trees (2006) in the heronry. The number of Black-headed Ibis nests was 145, 143, and 138 during the three years. This ibis was the last species to arrive and was observed forming sub-colonies. There was a significant increase in the proportion of nest materials and size as the nesting stages progressed. Nest morphometry revealed that the circumference of the nest was 155.66 ±44.33 cm and the width was 9.50 ±6.11 cm. Egg morphometry revealed that Black-headed Ibis produced larger eggs both in terms of length and mass than the other heronry species. Its clutch size was also the highest (6 ±2.16) among all the heronry species. Reproductive success was random in both space and time, their spatial location in the heronry being immaterial. Results of our analysis on vertical alignment of nests did not support the body mass-nest height hypothesis.

Key words: Black-headed Ibis, heronry, Bhitarkanika, nesting, Near Threatened

INTRODUCTION

Of the three populations of the Black-headed Ibis found globally, the East Asian population is alarmingly small, with an estimate of less than 100 individuals. The Southeast Asian and South Asian population of this species is estimated at 10,000 and 25,000 individuals each (Rose and Scott 1997) and their populations have been predicted to be declining across their range due to various reasons, ranging from habitat quality to poaching. The Black-headed Ibis is a widespread resident throughout India (Grimmett *et al.* 1998) and was recorded in Ceylon (now Sri Lanka), Burma (now Myanmar), China, South Japan (Whistler 1949), Bangladesh, and Pakistan (Ali 1977). This species prefers large marshes and jheels with wide areas of water covered with bushes and trees (Whistler 1949). It breeds in six of the 19 countries where it is distributed; this species has triggered the IBA (Important Bird Area) criteria for 13 IBAs across its range (BirdLife International 2012). In India, the species has triggered the IBA criteria for 5 IBA sites, i.e., Gudavi Bird Sanctuary, Harike Lake Bird Sanctuary, Karanji Lake, Narasambudhi Lake, and Vettangudi Bird Sanctuary (BirdLife International 2012). It inhabits freshwater marshes, lakes, rivers, flooded grasslands, paddy fields, tidal creeks, mudflats, salt marshes and coastal lagoons, usually in extreme lowlands, but occasionally up to 950 msl, tending to migrate locally in response to water levels and feeding conditions (Grimmett *et al.* 1998). It is vulnerable to drainage, disturbance, pollution, agricultural conversion, hunting and collection of eggs and nestlings (del Hoyo *et al.* 1992).

The Bhitarkanika mangrove harbours one of the largest congregations of breeding water birds in the country, and is one of the five largest heronries in India which hosts around 30,000 birds every year (Chadha and Kar 1999; Subramanya 1996). Eleven species of resident water birds are known to nest in this multi-species colony (Pandav 1996). The breeding birds in this mixed species colony are Asian Openbill (*Anastomus oscitans*), Great Egret (*Egretta alba*), Intermediate Egret (*Egretta intermedia*), Little Egret (*Egretta garzetta*), Eastern Cattle-Egret (*Bubulcus coromandus*), Grey Heron (*Ardea cinerea*), Purple Heron (*Ardea purpurea*), Black-crowned Night-Heron (*Nycticorax nycticorax*), Little Cormorant (*Phalacrocorax niger*), Oriental Darter (*Anhinga melanogaster*) and Black-headed Ibis (*Threskiornis melanocephalus*). The endangered Lesser Adjutant (*Leptoptilos javanicus*) and Painted Stork (*Mycteria leucocephala*) also breed in small colonies in the Park, which has recently been identified as an Important Bird Area (IBA) of India.

Long-term studies in India with the Black-headed Ibis as a focal species are limited, except for a few recent investigations (Balakrishnan and Thomas 2004; Devkar *et al.* 2006; Narayanan *et al.* 2006). We conducted this study to establish baseline data on the breeding biology, space-use patterns and food habits of this species in the Bhitarkanika

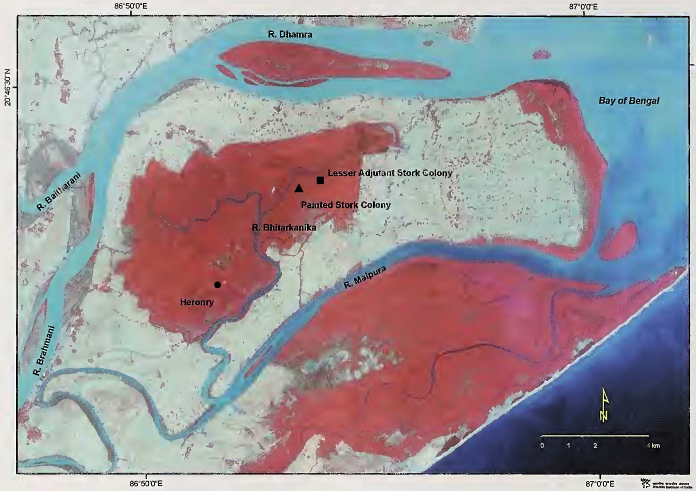

Fig 1: Map of Bhitarkanika Wildlife Sanctuary and location of the heronry inside the Park

heronry. This heronry is located on an island covered with mangrove vegetation. Enhanced foraging due to the presence of abundant foraging areas in and around the heronry in terms of wetlands and agricultural fields, decreased predation due to the remoteness of the nesting site, are supposed to be the major factors governing the large congregation of waterbirds in this heronry.

STUDY AREA

The study was conducted in Bhitarkanika National Park, Odisha. Bhitarkanika mangroves (20°04'–20°08' N; 86°45'–87°50' E), located on the east coast of India represent one of the finest remaining patches of mangrove forests in India (Fig. 1). The general elevation is between 1.5 and 2 msl; higher ground extends to 3–4 msl. The Sanctuary is bounded by the rivers Dhamara on the north, Maipura on the south, and Brahmani on the west; and the Bay of Bengal on the east. The 35 km coastline from the mouth of River Maipura till Barunei forms the eastern boundary of the Sanctuary. Annual rainfall ranges from 920 to 3,000 mm.

The heronry in Bhitarkanika is one of the oldest and largest mixed species waterbird colonies in India (Subramanya 1996). Over 30,000 birds breed every year in this heronry in a single unbroken patch of an area less than 5 ha, comprising 3,800 to 4,200 nest trees. Birds use five species of mangrove trees, namely *Excoecaria agallocha* (Guan), *Heritiera fomes* (Sundari), *Cynometra iripa* (Singada, Wrinkled Pod Mangrove), *Hibiscus tiliaceus* (Bania), *Tamarix troupii* (Jagula) for nesting in the heronry. The Asian Openbill is the most abundant nester in the heronry (66%), the least abundant being the Little Egret (0.8%).

METHODOLOGY

The study was conducted from August 2004 to December 2006. With the onset of the strong seasonal Southwest monsoon (early June), visits were made to the heronry. The entire heronry was girded into 17 blocks 50 m x 50 m each. Five trees were randomly selected from each block and marked with paint and white cloth for ease of identification. Selected trees were monitored on alternate days, and variables like tree species, nest height, nest initiation date (NID, i.e., date on which first nest materials were placed in a marked tree by a nesting pair), clutch initiation date (date of first egg being laid), egg laying dates, egg measurements, clutch size (total number of eggs per nest).

Egg morphometry was studied as follows: length (L) and breadth (B) of each egg were measured to the nearest 0.1 mm using callipers. Egg volume was calculated using the formula $V = 0.51 \times L \times B^2$ (Hoyt 1979). Nest measurements at different stages (i.e., laying, hatching, and fledgling) were measured using a measuring tape and nest material used were recorded.

Heronry Census

The census was carried out in the last week of August, just after the hatching of most birds was over. A total count of nest trees was carried out in the heronry and the tree number was painted on each. Parameters like tree species, tree height, girth at breast height (GBH), species nesting on the tree, number of nests, and nest height were recorded. Nest height and tree height were visually estimated to the nearest foot. GBH was measured with a measuring tape. The nest of the bird species was identified by observing the species guarding the nests. During the absence of both parent birds, the nest design and nest material were used to identify the species with minimal disturbance.

Behaviour

We used focal-animal sampling (Altmann 1974) to study the behaviour. Nesting birds were selected and observed for a maximum of four hours per sample. All observations of less than one minute were discarded. Copulation duration, incubation bout duration, and incubation interval time were recorded.

Breeding Biology

Once nest building started, each nest was marked with red oxide paint on a small aluminium tag below the branch that supported the nest, out of sight of the bird, with the tag bearing an alphanumeric code to identify individual nests. Nest checks were done concurrently by two observers in different parts of the colony. All observations were restricted to the cooler parts of the day (06:30 hrs to 08:00 hrs) to avoid over-heating while handling the eggs. The entire colony was not disturbed for more than one hour per monitoring. Birds left the nest when observers were within 2 to 5 m of the nest, however, they returned immediately once the observer moved away. Nest progress was followed until the chicks fledged. Nest checks continued till the last chick had fledged. We considered the young successfully fledged when they were old enough to fly across open space to trees away from the nest. Observers approached the nest along one route and left by another. This would minimise predators' opportunities to determine nest location by watching observer activities or by following scent trails.

For studying nest morphometry, nest circumference and width was measured using an inch tape. Hatching success was calculated by considering a nest as successful on hatching of a single egg. Productivity was calculated as number of chicks that survived till the fledglings dispersed from the nest. Unless indicated otherwise, errors presented in the text are the Standard Deviation of Mean (1 SD).

Analysis

Relationship between tree height and number of nests: Since the scatterplot showed a non-linear association, non-linear regression was performed. The relationship was found to follow quadratic model ($r = 0.54$, F Significance<0.01).

Species preference of nesting trees: We developed a simple and straightforward preference index (PI) to investigate nesting tree preference by water birds.

$$PI = -1 \times [1 - F(obs) / F(exp)]$$

Where:

F (obs) = Observed number of nests on the given tree species.

F (exp) = Expected number of nests calculated as the relative proportion of the number of tree species.

The final value ranges from -8 to +8, where 0 refers to random selection. Increasing values on positive scale indicate preference, while negative scores point to avoidance. For clarity, we predefine the index value of 1 to = 3 as zone of preference and -1 to = -3 as zone of avoidance. The scores ranging from -1 to +1 are treated as evidence for the random choice of the nesting tree.

Spatial association / co-occurrence of nesting species in the heronry: Pearson's Chi-square Statistic # P>0.05 (indicating spatial independence of nests) was carried out to understand the association between nesting species in the heronry. All statistical analyses were carried out using the statistical package SPSS 8.0.

RESULTS

Excoecaria agallocha was the most numerous tree species in the heronry and *Heritiera fomes* was found to be the tallest and stoutest tree species in the heronry (Figs 2a,b). The results to verify the relationship between tree height/ GBH and number of nests revealed that it followed the quadratic model (Figs 3a,b). The number of nests increased with increasing GBH/tree height up to a certain value, after

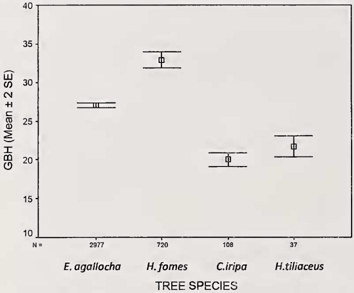

Fig. 2a: Relationship between tree species and Girth at Breast Height at Bhitarkanika heronry

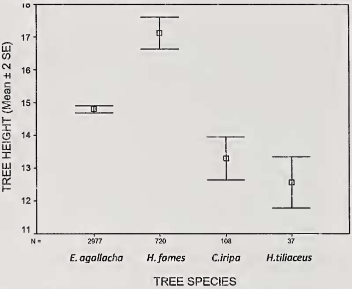

Fig. 2b: Relationship between tree species and tree height at Bhitarkanika heronry

which it declined. This is because the tall and old trees occupied the peripheral region of the heronry where most birds did not prefer to nest. Most of the birds preferred trees in the centre for nesting which were shorter and thinner compared to the peripheral ones.

Excoecaria agallocha was preferred by Black-headed Ibis to nest and the top canopy was mostly preferred for nests (Figs 5a,b). The results of the spatial association and co-occurrence of nesting species in the heronry revealed that the Black-headed Ibis showed a strong dissociation with other colonial species except for Great and Intermediate Egrets and tended to nest in sub-colonies inside the heronry (Table 1).

The Black-headed Ibis nest numbers were 145, 143, and 138 during 2004, 2005, and 2006 (Fig. 4). There has been a gradual decline in nest numbers since the first census was carried out in 1994. The Black-headed Ibis built 'platform nests', which consisted of irregularly placed, loose assemblage of plant materials. The platform nests were very simple in structure, being flat areas with a slight depression to hold the eggs. Most of the nest materials were chosen from the immediate surroundings, which result in inconspicuous or camouflaged nest. Nest profile in the heronry varied between species in relation to the body mass (Table 2), Grey Heron built the largest nest in contrast to Little Cormorant that built the smallest nest with few sticks in them. The nest size correlated to the body mass index of the nesting species, i.e., the larger the body mass of the species, the larger were the nest morphometrics.

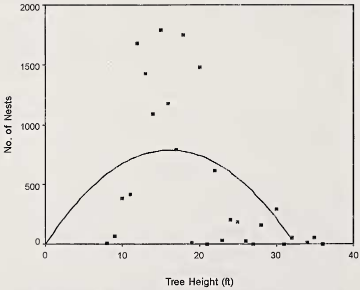

Fig. 3a: Relationship between tree height and number of nests at Bhitarkanika heronry

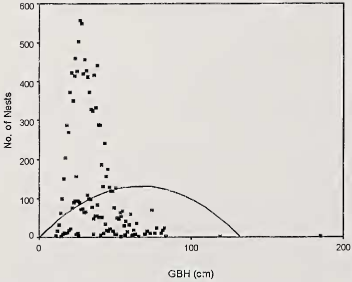

Fig. 3b: Relationship between Girth at Breast Height (GBH) and number of nests at Bhitarkanika heronry

Fig. 4a: Monthly rainfall in Bhitarkanika mangroves

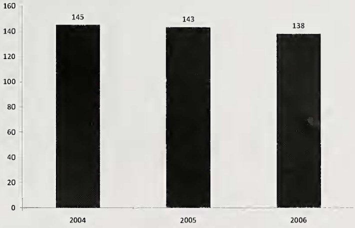

Fig. 4b: Number of enumerated nests in each month by all the nesting species

Nest material that were collected and used for nest building by the Black-headed Ibis were as follows: *Excoecaria agallocha*, *Heritiera fomes*, *Hibiscus tiliaceus*, *Tamarix troupii*, *Cynometra iripa*, *Salvadora persica*, *Salacia prinoides*, and *Avicennia officinalis*. Both dry and green plant materials were used (Fig. 6). There is a significant increase in the proportion of nest materials and size with increase in the breeding stage, i.e., laying, hatching, and fledgling stage (Table 3). Nest materials were added by both parents till the chicks fledged in all the species to provide enough space for the growing chicks to reside in the nest.

Egg morphometry studies revealed that Black-headed Ibis produces larger eggs both in length and mass, while Little Cormorant produced smaller eggs both in length and mass (Table 4). The variability in the nest initiation date to clutch initiation date revealed 8–10 days for herons and egrets, while Little Cormorants and Darters took 15–18 days to initiate the clutch. However, the Black-headed Ibis took less than one week from the nest initiation date to initiate clutch (Table 5). The Black-headed Ibis is the last species to arrive at the heronry and as soon as the birds arrive, they start building the nests and lay the clutch immediately. Asian Openbill showed a delayed clutch initiation of 30 days after nest initiation, which is presumably due to delay in monsoon. The clutch size varied between 2.5 eggs to 6 eggs per clutch across all species. Black-headed Ibis had the largest mean clutch size (6 ±2.16) followed by Darter and Little Cormorant, and Black-crowned Night-Heron had the smallest clutch size with less than 3 eggs per clutch (Table 6). Incubation started soon after the first egg laying. Black-headed Ibis and Little Egret showed the least mean incubation duration (18 and 19 days respectively) while Darter and Asian Openbill showed larger mean incubation duration (28 and 26 days respectively) (Table 7).

Productivity in terms of hatching and fledgling success was very low (<50%) for most species, especially for the Black-headed Ibis in the breeding colony. Only Purple Heron and Darter showed higher reproductive success with >50% eggs surviving till fledgling stage (Table 8). Since breeding success was known to differ between centre and edge nests (Balda and Bateman 1972; Brown and Brown 1987; Coulson 1968) the reproductive success was compared between edge nests and core nests, which revealed no difference in success rate, indicating that reproductive success was random at both space and time, regardless of their spatial location (Table 9). The results of our analysis on vertical alignment of nests did not support the body mass-nest height hypothesis, which postulates a direct positive correlation between body weight and nest height among colonial waterbirds (Fig. 7).

Table 1: Spatial association / co-occurrence of Black-headed Ibis with other nesting species in the heronry

Species	Asian Openbill	Little Cormorant
Black-headed Ibis	140.6 P = 0.753	182.1 P<0.0001

*Pearson's Chi-square Statistic # P>0.05 (indicating spatial independence of nests)

Table 2: Nest measurements of breeding species including Black-headed Ibis

Species	n	Nest Measurements (cm)	
		Circumference	Width
Grey Heron	20	217.17 ±19.05	66.17 ±11.46
Large Egret	30	172.83 ±13.0	50.3 ±4.9
Purple Heron	10	169.00 ±16.66	55.00 ±8.62
Intermediate Egret	10	168.5 ±13.86	43.5 ±4.10
Asian Openbill	20	166.1 ±16.3	52.1 ±6.3
Darter	20	162.25 ±19.15	43.25 ±7.5
Black-headed Ibis	10	155.66 ±44.33	9.50 ±6.11
Little Egret	5	144 ±7.21	45.66 ±8.50
Black-crowned Night-Heron	4	132 ±7.25	32 ±4.86
Little Cormorant	11	128 ±11.96	34 ±3.0

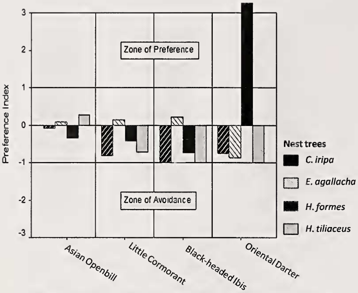

Fig. 5a: Nest tree preference of Openbill, Little Cormorant and Black-headed Ibis

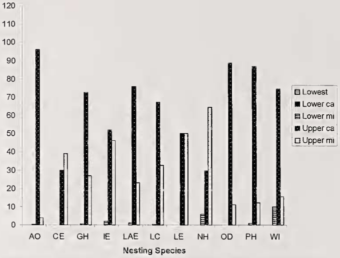

Fig. 5b: Nest location in nesting trees at the Bhitarkanika heronry

Table 3: Proportion of nest materials in various nesting stages (laying, hatching and fledgling) among colonial waterbirds in Bhitarkanika heronry

Species	Friedman rank chi-square	N	Df	p-value	Result
Asian Openbill	10	20	2	0.007	Sig
Large Egret	10	20	2	0.007	Sig
Grey Heron	10	20	2	0.007	Sig
Oriental Darter	10	20	2	0.007	Sig
Purple Heron	10	20	2	0.007	Sig
Little Cormorant	10	20	2	0.007	Sig
Intermediate Egret	8	20	2	0.018	Sig
Black-crowned Night-Heron	2	20	2	0.368	Non-sig
Black-headed Ibis	6	20	2	0.05	Sig
Little Egret	10	20	2	0.007	Sig

DISCUSSION

Decline of Black-headed Ibis: The nest census of this heronry was first conducted in 1994 (Bivash Pandav, pers. comm.), and the Black-headed Ibis numbers are showing a gradual decline over the years. The Black-headed Ibis is considered to be declining at a slow to moderate rate across its range (BirdLife International 2012). On a global level, the main factors attributed for the species decline are egg collection, disturbance in breeding colonies, drainage and agriculture conversion (BirdLife International 2012). The Bhitarkanika heronry is present inside the Park and is accorded the highest level of protection. Hence, the disturbances to the colonies due to direct anthropogenic impacts are nearly negligible. The reasons for the decline of the species in this colony despite good protection need further investigation.

Ali and Ripley (1968) reported that this bird lays around 2-4 eggs, however, in Bhitarkanika most of the clutches examined contained more than 4 eggs. In fact the clutch size was highest at 6 ±2.16 when compared with other species in

Table 4: Egg morphometry of Black-headed Ibis with other colonial nesters in Bhitarkanika heronry

Species	N	Mean egg length (mm)	Mean egg width (mm)	Mean egg mass (cm^3)
Asian Openbill	84	42.06 ±8.48	26.96 ±5.38	16.84 ±3.92
Large Egret	74	37.22± 8.17	24.91 ±5.82	13.01 ±4.44
Intermediate Egret	30	33.67± 2.31	22.77 ±1.83	9.00 ±1.90
Little Egret	19	30.58 ±2.57	20.58 ±1.17	6.59 ±0.60
Grey Heron	64	43.30 ±6.00	29.59 ±4.92	20.18 ±5.37
Purple Heron	51	40.33 ±6.37	25.96 ±4.52	14.66 ±4.49
Black-crowned Night-Heron	13	33.46 ±2.26	21.08 ±1.98	7.70 ±1.95
Black-headed Ibis	60	51.15 ±2.66	30.03 ±1.82	23.68 ±3.37
Little Cormorant	49	32.18 ±5.25	15.92 ±2.98	4.39 ±1.11
Darter	98	37.96 ±6.17	20.07 ±3.23	8.19 ±1.82

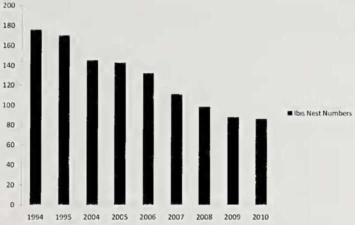

Fig. 6: Nesting trend of Black-headed Ibis in Bhitarkanika heronry

Source: 1994-1995 Dr. Bivash Pandav (pers. comm.), 2004-2006. This study and 2007-2010 – Mangrove Forest Division, Rajnagar, Odisha

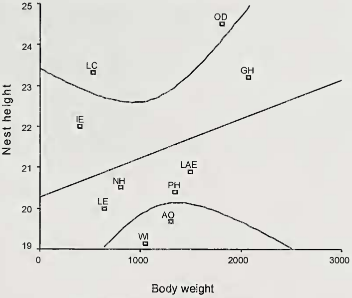

Fig. 7: Body mass vs. Nest height

the heronry. In spite of having the largest clutch size, hatching success was documented to be poor 15.74 ±21.43 (in %, n = 10) for this species in the colony and the exact reasons could not be ascertained. This poor success rate could also be a reason for their gradual decline in numbers.

Breeding biology: Black-headed Ibis builds platform nests and forms sub-colonies inside the heronry. The species built the nests quickly on arrival to the heronry and took just 5.50 ±0.71 days from nest initiation to clutch initiation. As mentioned earlier, the clutch size was highest for this species. The factors governing the clutch size have been of great academic interest in the discipline of evolutionary ecology in particular (Stearns 1976, 1992). The hypothesis proposed by Lack (1947, 1954, 1968) has garnered greater acceptance. Other workers suggest competition and environmental conditions to limit clutch sizes (Ashmole 1963; Cody 1966; Koenig 1984; Ricklefs 1980). Slagsvold (1982) suggests that predation or food supply for fledglings during the breeding season influences clutch size. Further empirical studies are required at Bhitarkanika heronry to determine the exact factors that govern the clutch size, which is larger than the previously reported studies.

The results of the Black-headed Ibis egg morphometry revealed that the average size of the eggs was 51.15 ±2.66 and 30.03 ±1.82 (n = 60), however, this result completely differed from that of Ali and Ripley (1968) who documented the egg size of Black-headed Ibis to be 63.5 x 43.1 (n = 150). This might be due to the fact that we had access to limited eggs and the sample size of Ali and Ripley (1968) was more than double of ours. The incubation period of the bird species in the heronry was 19.56 ±1.13 days; Ali and Ripley (1968) reported 23-25 days.

Table 5: Variability in nest initiation date and clutch initiation date across species in Bhitarkanika heronry

Species	n	Mean number of difference in days
Asian Openbill	20	30.53 ±8.50
Large Egret	30	9.19 ±3.50
Intermediate Egret	10	9.67 ±3.97
Little Egret	5	8.40 ±3.21
Grey Heron	20	10.17 ±11.62
Purple Heron	12	8.08 ±1.83
Black-crowned Night-Heron	5	5.20 ± .79
Black-headed Ibis	10	5.50 ±0.71
Little Cormorant	11	16.82 ±9.54
Darter	20	18.89 ±9.41

Table 6: Mean clutch size of Black-headed Ibis wrt other bird species breeding in Bhitarkanika heronry

Species	Clutch size
Black-headed Ibis	6 ±2.16
Darter	5.17 ±1.42
Little Cormorant	4.45 ±1.36
Asian Openbill	4.36 ±2.90
Purple Heron	4.25 ±1.86
Little Egret	3.8 ±1.09
Grey Heron	3.70 ±1.53
Intermediate Egret	3.33 ±1.80
Black-crowned Night-Heron	2.6 ±0.54
Large Egret	2.84 ±1.18

Table 7: Incubation duration of bird species nesting in Bhitarkanika heronry

Species	n	Mean number of days
Darter	49	28.55 ±8.86
Asian Openbill	38	26 ±2.84
Intermediate Egret	13	25.70 ±4.90
Large Egret	23	25.17 ±1.40
Purple Heron	30	24.73 ±3.27
Grey Heron	16	23.63 ±2.31
Black-crowned Night-Heron	12	23.25 ±0.96
Little Cormorant	15	22.10 ±2.23
Black-headed Ibis	23	19.56 ±1.13
Little Egret	14	18 ±3.06

Table 8: Variability in hatching success across species

Species	n	Hatching Success %
Purple Heron	12	57.74 ±36.62
Darter	20	50.22 ±37.91
Asian Openbill	20	45.24 ±38.64
Intermediate Egret	10	41.67 ±43.30
Little Egret	5	38.00 ±37.52
Large Egret	30	33.07 ±43.91
Little Cormorant	11	29.55 ±43.04
Grey Heron	20	22.22 ±40.12
Black-headed Ibis	10	15.74 ±21.43
Black-crowned Night-Heron	5	15.00 ±33.54

The reproductive success was random, regardless of their spatial location at the heronry, disproving the well-proven hypothesis that breeding success may differ between centre and edge nests in colonial breeders. Many authors have documented that the peripheral/edge nesters suffer from higher predation in comparison to the centre nesters, as the centre nesters have more neighbours that defend probable predators as suggested in the 'selfish herd hypothesis' (Brown and Brown 1987; Kruuk 1964; Spear 1993; Wittenberger and Hunt 1985). Some authors have also suggested that the males preferred to establish their territories within the centre (Kittywake *Rissa tridactyla* – Coulson 1968; Least Tern – Burger 1988).

Space-use pattern: Black-headed Ibis was observed to nest away from most of the species within the heronry, forming sub-colonies on its own. The Ibis, though it arrives last in the heronry, tends to nest in the central location by displacing established nests of smaller birds like Great Egret, Intermediate Egret, and Little Egret. One other major factor to partition the space is by nest tree preference. The Black-headed Ibis, Asian Openbill, Little Cormorant, and Intermediate Egret showed a strong preference for nesting in *Excoecaria agallocha* trees.

Table 9: Comparison of hatching success Black-headed Ibis between central and edge nests

Nesting Variable	Mann-Whitney U	n	p-value
Clutch size	32.5	18	0.572
Clutch mass	23.0	18	0.172
Hatching success %	33.5	18	0.130
Fledgling success %	33.5	18	0.130

Correlation is significant at the 0.05 level (2-tailed)

Certain studies have suggested that within homogenous vegetation, nesting birds partition the space by aligning their nests vertically in relation to their body length, i.e., the larger species nesting in the top and small species in the lower canopies. Some studies (Burger and Gochfeld 1990) did not validate this hypothesis, and the occupancy of a nest site is attributed mainly to the arrival times and the aggressive dominance of the larger species (Burger 1978, 1982). Our results on vertical alignment of nests did not support the body mass-nest height hypothesis, which postulates a direct positive correlation between body weight and nest height among colonial waterbirds.

CONCLUSION

This study attempted to establish a baseline information for Black-headed Ibis in Bhitarkanika heronry. Long term ecological studies are further required to investigate the probable causes for gradual population decline in this heronry, poor hatching and fledgling success. The probable threats that require immediate academic and conservation attention are the problems of excessive predation and toxic contaminants (organochlorine pesticides and heavy metals) found in the food web of this species. It is also critical to know about the entire life cycle of the species (during both breeding and non-breeding periods). Hence, studies to document their foraging areas, habitat use during non-breeding periods and mapping of

Table 10: Number of regurgitated boluses analysed

Species	Number of regurgitated boluses
Black-headed Ibis	31
All other nesting species	1,422

breeding colonies should be carried out, which will aid in identifying key areas for conserving this species and making informed conservation decisions.

ACKNOWLEDGEMENTS

We sincerely thank Mr. P.R. Sinha, Director, and Dr. V.B. Mathur, Dean, Wildlife Institute of India, for providing logistical and infrastructure support while conducting the study. The Odisha Forest Department is thanked for providing necessary permits to execute this study. We also sincerely thank Dr. Rajah Jayapal, Scientist at SACON, for help in data analysis. We are grateful to Dr. Panna Lal for preparing the map. Field assistants, Mr. Bijoy and Mr. Kirodh, are thanked for their hard work rendered during the entire duration of the study.

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